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Takashima et al.

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(54) **NETWORK SYSTEM AND NETWORK MANAGING METHOD**

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H04L 12/24 (2006.01)
H04L 29/12 (2006.01)
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CPC ***H04L 41/00*** (2013.01); ***H04L 41/0806*** (2013.01); ***H04L 45/38*** (2013.01); ***H04L 61/10*** (2013.01); ***H04L 61/103*** (2013.01); *H04L 47/20* (2013.01)

(58) **Field of Classification Search**
CPC H04L 45/38; H04L 45/42; H04L 41/00; H04L 41/0806; H04L 47/20; G06F 2009/4557; G06F 9/4856; G06F 9/4862; G06F 9/4868; G06F 9/4875; G06F 9/5088
See application file for complete search history.

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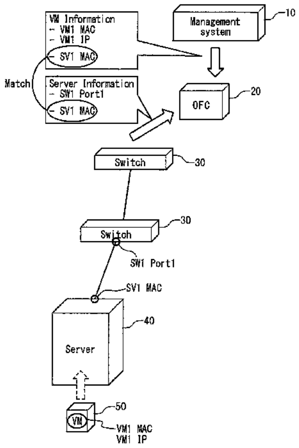
(57) **ABSTRACT**

A controller completes the setting of a flow entry to a switch previously before the communication of a virtual machine starts. Specifically, the controller sets information of the virtual machine and information of a server on which the virtual machine operates. The controller detects the information of the server under the switch through the switch. When the set server information and the detected server information match to each other, the controller sets a flow entry for a packet destined to the virtual machine to the switch based on information of the virtual machine on the server. After that, the virtual machine starts communication.

13 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

H04L 12/721	(2013.01)
H04L 12/813	(2013.01)

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Fig. 1

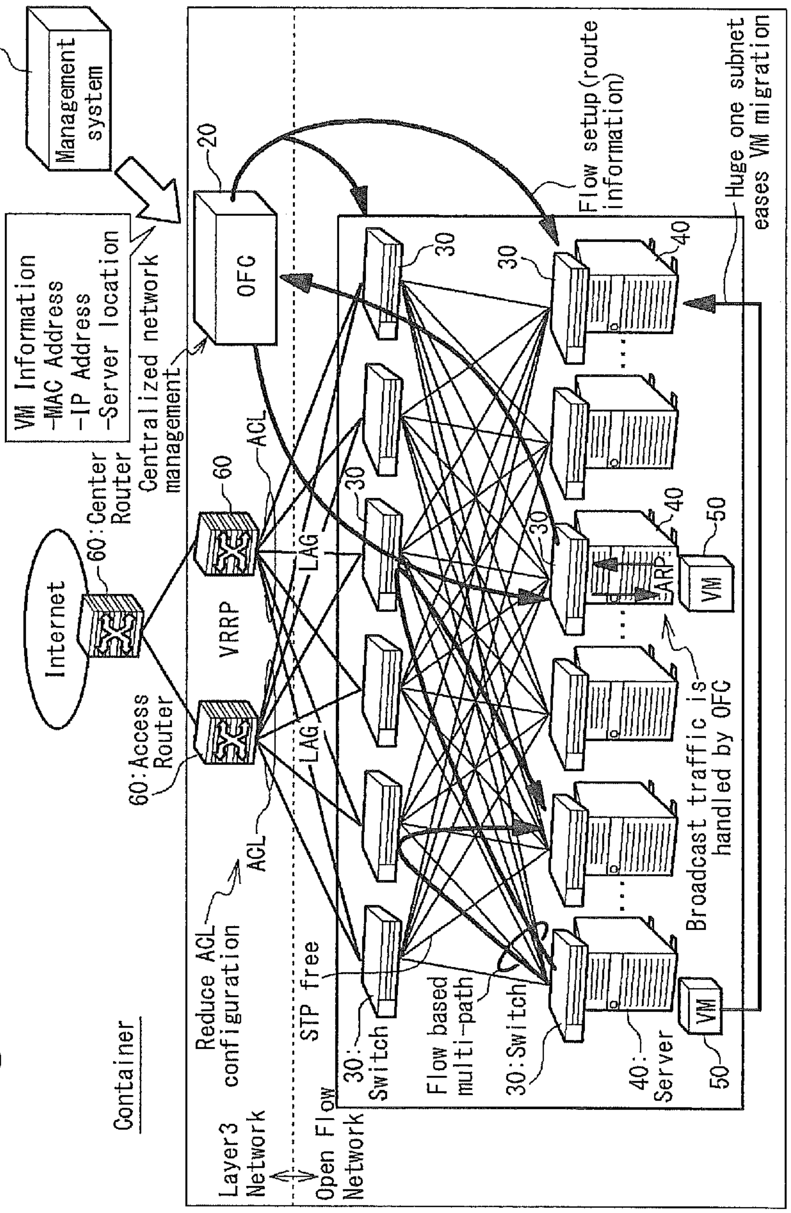

10
Management system
VM Information
-MAC Address
-IP Address
-Server location
Centralized network management
20
OFC
Flow setup (route information)
Internet
60: Center Router
60: Access Router
60
VRRP
ACL
ACL
LAG
LAG
Container
Reduce ACL configuration
STP free
Layer3 Network
Open Flow Network
30: Switch
30: Switch
30
30
30
30
Flow based multi-path
40: Server
40
40
ARP
50
50
VM
VM
Broadcast traffic is handled by OFC
Huge one subnet eases VM migration

Fig. 2

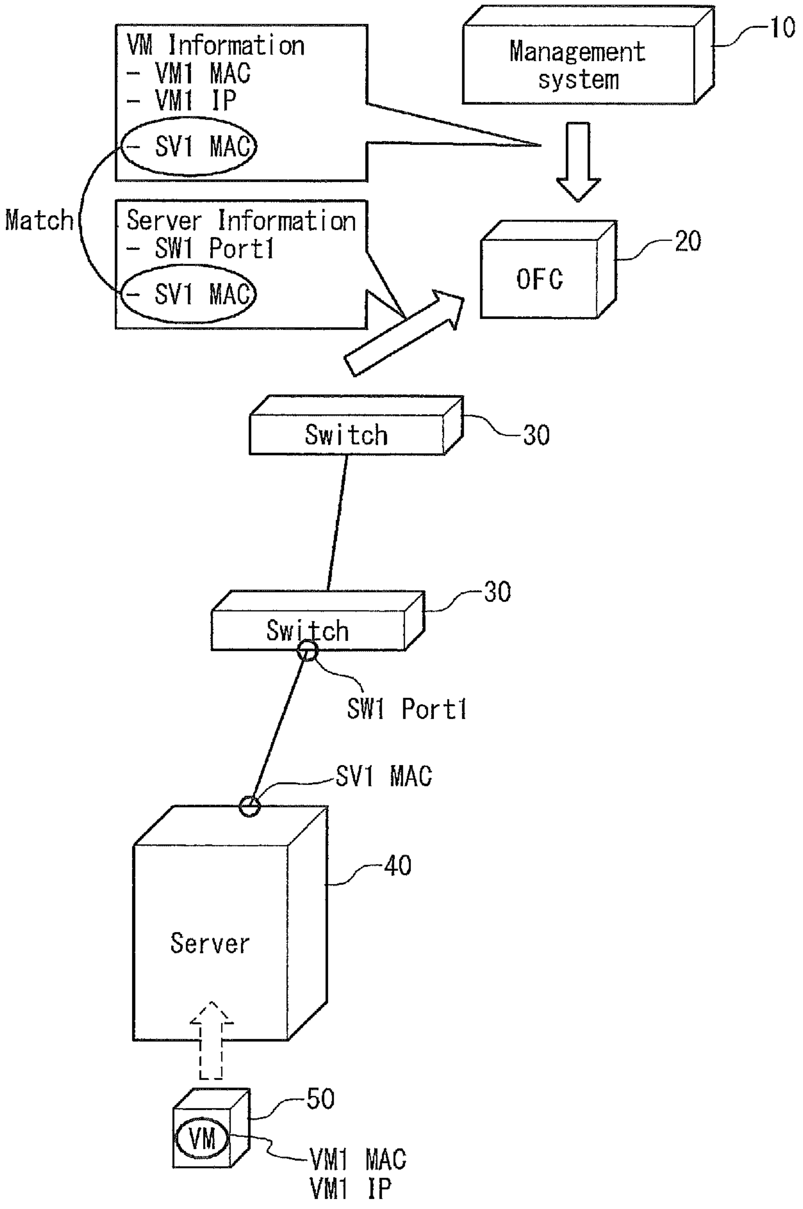

VM Information
- VM1 MAC
- VM1 IP
- SV1 MAC
Management system
10
Match
Server Information
- SW1 Port1
- SV1 MAC
OFC
20
Switch
30
Switch
30
SW1 Port1
SV1 MAC
40
Server
50
VM
VM1 MAC
VM1 IP

Fig. 3

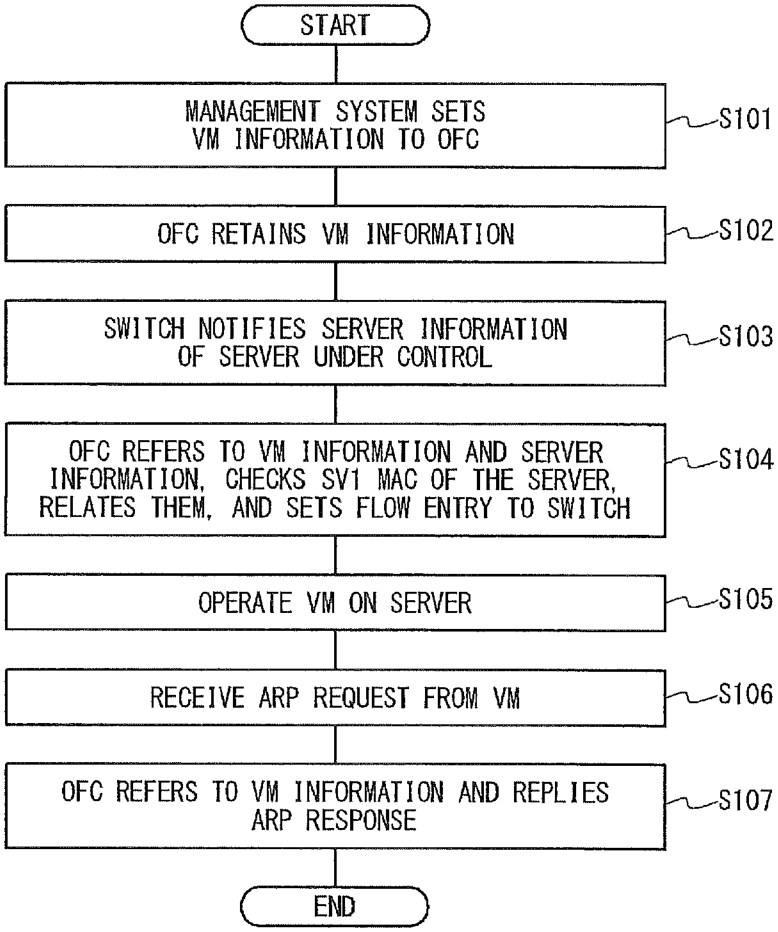

START
MANAGEMENT SYSTEM SETS VM INFORMATION TO OFC
S101
OFC RETAINS VM INFORMATION
S102
SWITCH NOTIFIES SERVER INFORMATION OF SERVER UNDER CONTROL
S103
OFC REFERS TO VM INFORMATION AND SERVER INFORMATION, CHECKS SV1 MAC OF THE SERVER, RELATES THEM, AND SETS FLOW ENTRY TO SWITCH
S104
OPERATE VM ON SERVER
S105
RECEIVE ARP REQUEST FROM VM
S106
OFC REFERS TO VM INFORMATION AND REPLIES ARP RESPONSE
S107
END

Fig. 4

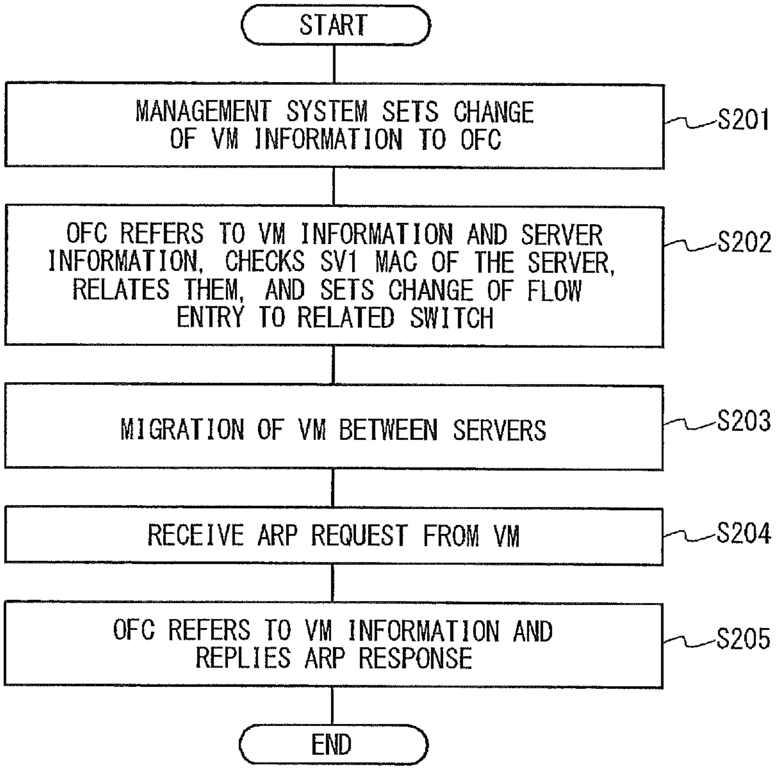
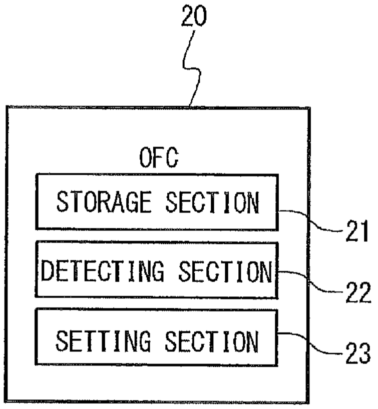

START
MANAGEMENT SYSTEM SETS CHANGE OF VM INFORMATION TO OFC
S201
OFC REFERS TO VM INFORMATION AND SERVER INFORMATION, CHECKS SV1 MAC OF THE SERVER, RELATES THEM, AND SETS CHANGE OF FLOW ENTRY TO RELATED SWITCH
S202
MIGRATION OF VM BETWEEN SERVERS
S203
RECEIVE ARP REQUEST FROM VM
S204
OFC REFERS TO VM INFORMATION AND REPLIES ARP RESPONSE
S205
END

Fig. 5


20
OFC
STORAGE SECTION
DETECTING SECTION
SETTING SECTION
21
22
23

NETWORK SYSTEM AND NETWORK MANAGING METHOD

TECHNICAL FIELD

The present invention relates to a network system, and in particular, to a network system using a CU (C: Control plane/U: User plane) separate-type network.

BACKGROUND ART

A system in which a user plane such as a switch and a terminal is controlled by a control plane such as an external controller is called as a system of CU (C: Control plane/U: User plane) separate-type architecture. A network configured on the basis of the CU separate-type architecture is called as a CU separate-type network.

As an example of the CU separate-type network, an OpenFlow network using an OpenFlow technique is exemplified which controls switches from a controller to perform a route control of the network.

Explanation of OpenFlow Network

In the OpenFlow network, a controller such as an OFC (OpenFlow Controller) manipulates a flow table of a switch such as an OFC (OpenFlow Switch) to control the behavior of the switch. The controller and the switch are connected through a secure channel-in which the controller controls the switch by using a control message compliant with an OpenFlow protocol.

Switches in the OpenFlow network configure an OpenFlow network and are referred to as edge switches or core switches under control of the controller. A series of transfer processes of a packet from reception of the packet at an input side edge switch to transmission of the packet at an output side edge switch in the OpenFlow network is referred to as a flow.

The flow table is a table in which a flow entry is registered that defines a predetermined processing content (action) to be performed on the packet (communication data) that matches a predetermined matching condition (rule).

The rule of the flow entry is distinguishable and defined based on various combinations of any or all of a destination address, a source address, a destination port, and a source port included in a header region of the packet in a protocol layer. It should be noted that the addresses described above are supposed to include a MAC (Media Access Control) address and an IP (Internet Protocol) address. Also, in addition to the above, information on an ingress port can also be used as a part of the rule of the flow entry.

The action of the flow entry indicates an action of "output to a specific port", "discard", or "rewrite of a header". For example, if identification information of an output port (an output port number) is indicated for the action of the flow entry, the switch outputs a packet to a port corresponding to the identification information, whereas, if the identification information of the output port is not indicated, the switch discards the packet. Alternatively, if header information is indicated for the action of the flow entry, the switch rewrites a header of the packet on the basis of the header information.

The switch in the OpenFlow network performs an action defined in the flow entry on a packet group (a packet sequence) meeting a rule of the flow entry.

Details of the OpenFlow technique have been described in Non-Patent Literatures 1 and 2.

When a virtual machine (VM) operates on a server under a switch in a network system using the OpenFlow technique, the controller is requested to receive an ARP (Address Resolution Protocol) request from the generated virtual machine through the switch, every time the virtual machine is generated on the server under the switch. Moreover, the controller is requested to identify identification information and location information (server information) of the virtual machine, and set a flow entry for a packet destined to the virtual machine to the switch. For this reason, such processes are concentrated on the controller and therefore a large load is imposed on the controller.

For example, when tens of virtual machines operate on each of thousands of physical servers connected to a network, tens of thousands of to hundreds of thousands of virtual machines in total are in the operation state. A load imposed on the controller is enormous when the controller receives the APR request from not the physical servers but each of the virtual machines, identifies the identification information and location information of the virtual machine, and sets a flow entry for a packet destined to the virtual machine to the switch on the basis of such pieces of information.

CITATION LIST

[Non-Patent Literature 1] "The OpenFlow Switch Consortium" <http://www.openflowswitch.org/>

[Non-Patent Literature 2] "OpenFlow Switch Specification Version 1.0.0 (Wire Protocol 0x01) Dec. 31, 2009" <http://www.openflowswitch.org/documents/openflow-spec-v1.0.0.pdf>

SUMMARY OF THE INVENTION

An object of the present invention is to provide a network system in which a controller manages identification information of a virtual machine which operates on a server under a switch and identification information of the server and sets a flow entry to the switch in parallel to generation of the virtual machine and an operation of migration.

The network system according to the present invention includes a management system configured to manage a network, a controller configured to retain information of a server in accordance with to a setting from the management system, and a switch configuring the network, and configured to register a flow entry in which a rule and an action are defined, according to a control from the controller to uniformly control a packet as a flow, and to execute the action of the flow entry to the packet which matches the rule of the flow entry. The controller calculates a communication route to the server based on the set information of the server, and sets the flow entry for the packet destined the server to the switch.

The controller according to the present invention includes a storage section which retains information of a server which is set by a management system managing a network, and a processing section which calculates a communication route to the server based on the set information of the server, and sets the flow entry for the packet destined the server to a switch which configures the network, and transfers a reception packet according to the set flow entry.

In a network managing method according to the present invention, a computer functioning as a controller retains information of a server set from a management system which manages a network. Also, the controller calculates a communication route to the server based on the set information of the server, and sets the flow entry for a packet destined to the server to a switch which configures the network and transfers a reception packet according to the set flow entry.

A program according to the present invention is a program which makes a computer execute: retaining information of a server set from a management system which manages a network, calculating a communication route to the server based on the set information of the server, and setting the flow entry for a packet destined to the server to a switch which configures the network and transfers a reception packet according to the set flow entry. It should be noted that the program according to the present invention can be stored in a storage unit and a storage medium.

In this way, in the network system using the OpenFlow technique, when a virtual machine is generated on a server under a switch, a load imposed on a controller can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a conceptual diagram illustrating a configuration example of a network system according to the present invention;

FIG. **2** is a diagram showing a process of checking preset information and actually detected information in the present invention;

FIG. **3** is a flowchart illustrating a registering process of setting information in the present invention;

FIG. **4** is a flowchart illustrating a changing process of the setting information in the present invention; and

FIG. **5** is a functional block diagram illustrating a configuration example of a controller according to the present invention.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

The present invention relates to a CU separate-type network. Here, the OpenFlow network, which is one of the CU separate-type networks, will be described as an example. It should be noted that the present invention is not limited to the OpenFlow network.

[First Exemplary Embodiment]

A first exemplary embodiment of the present invention will be described with reference to the attached drawings.

(System Configuration)

As illustrated in FIG. **1**, a network system according to the present invention includes a management system **10**, a controller (OFC: OpenFlow controller) **20**, a switch **30**, servers **40**, a virtual machine (VMs) **50**, and a router **60**.

There may be a plurality of management systems **10**, a plurality of controller **20**, a plurality of switches **30**, a plurality of servers **40**, a plurality of virtual machines **50**, and a plurality of routers **60**. That is, at least one management system **10**, one controller **20**, one switch **30**, one server **40**, one virtual machine **50**, and one router **60** are supposed to be present.

The management system **10** manages nodes or services in the CU separate-type network. The management system **10** manages the switches, the routers, and the servers. For example, the management system **10** manages the network by using hardware and software configurations for realizing an NMS (Network Management System) or an EMS (Element Management System). Also, the management system **10** sets a virtual MAC address and a virtual IP address of each of the virtual machines, and a physical MAC address of a server on which the virtual machines operate, to the controller **20** as virtual machine information (VM information). Here, the virtual machine information is supposed to be set in the management system **10** in advance.

It should be noted that the virtual MAC address, the virtual IP address, the physical MAC address are only an example of location information on the network. Actually, the location information is not limited to the MAC address or IP address, but is enough if it is information for identifying the virtual machine or the server.

The controller **20** controls the CU separate-type network. The controller **20** performs a route control of the switches **30** according to setting by the management system **10**. Here, it is supposed that the controller **20** is a controller compliant with the OpenFlow technique, and a flow entry for a packet destined to the server is set to the switch on the basis of the physical MAC address of the server notified from any of the switches **30**.

Also, as the virtual machine information, the controller **20** retains a table in which the virtual MAC address and the virtual IP address of each of the virtual machines and the physical MAC address of the server on which the virtual machines operate are related to each other, according to the settings by the management system **10**. As illustrated in FIG. **2**, the controller **20** checks the physical MAC address of the server set by the management system **10** and the physical MAC address of the server notified from the switch **30**, and, if the physical MAC addresses match with each other, relates both of them to each other. Also, the controller **20** sets a flow entry for the packet destined to the virtual machine to the switches **30** on the basis of the virtual MAC address and virtual IP address of the virtual machine on the server.

Referring to FIG. **2**, the controller **20** checks the physical MAC address ("SV1 MAC" of "VM information") of the server set by the management system **10** and the physical MAC address ("SV1 MAC" of "Server Information") of the server notified from the switch **30**. Here, the physical MAC addresses match with each other, and therefore the controller **20** relates the physical MAC addresses to each other, and sets the flow entry for the packet destined to the virtual machine to the switches **30** on the basis of the virtual MAC address and virtual IP address ("VM1 MAC" and "VM1 IP" of "VM information") of the virtual machine on the server.

Also, when a change of the physical MAC address of the server on which the virtual machine operates is notified through the setting by the management system **10**, the controller **20** sets the change of the flow entry for the packet destined to the virtual machine to the switch **30**. For example, when the switches **30** on the current route are changed due to the change of the physical MAC address of the server, the controller **20** deletes the flow entry, which has been set to the switches **30** on the current route, for the packet destined to the virtual machine, and sets the flow entry for the packet destined to the virtual machine to switches **30** corresponding to a server after the change.

Further, when an ARP (Address Resolution Protocol) request is sent from the virtual machine after the flow entry for the packet destined to the virtual machine is set to the switches **30**, the controller receives the ARP request from the virtual machine through the switches **30**, and refers to the virtual MAC address and virtual IP address of the virtual machine, which are retained as the virtual machine information. Thus, the controller **20** sends an ARP response to the virtual machine on the basis of relevant information.

Each of the switches **30** performs a packet transfer in the CU separate-type network. Here, each of the switches **30** is a switch compliant with the OpenFlow technique, and supposed to retain a flow table. When any of the switches **30** is connected with the server **40** under the control of it, the switch

30 detects the physical MAC address of the server **40** at the time of receiving the ARP request from the server **40**, and notifies the physical MAC address of the server **40** to the controller **20**. Alternatively, the switch **30** may notify the physical MAC address of the server to the controller **20**, by receiving the ARP request inquiring the physical MAC address of the server **40** from the controller **20**, transferring the ARP request to the server **40**, and transferring the ARP response from the server **40** to the controller **20**. This is because it is considered that the number of physical servers is small as compared with the number of virtual servers, so that a load imposed on the controller is only relatively small, if a process of inquiring identification information of the physical server is only performed. At this time, the switch **30** notifies a port number of the switch **30** connected to the server to the controller **20** in addition to the physical MAC address of the server, as the server information. Thus, the controller **20** can recognize that the server **40** is under control of the switch **30**.

Each of the servers **40** is a physical server under the control of a corresponding switch **30**, and provides service in the CU separate-type network. Here, each of the servers **40** manages corresponding virtual machines (VM) **50**. The virtual machine (VM) **50** can operate on the server **40**. For example, the server **40** generates the virtual machine **50** by a virtual machine monitor (VMM) such as a hypervisor to make the virtual machines **50** operate. It should be noted that a role and application of the server **40** are not limited to those in the above example.

Each of the virtual machines **50** is a virtual machine (VM) operating on a corresponding server **40**. A set of a virtual MAC address and a virtual IP address for each of the virtual machines **50** is one of sets of virtual MAC addresses and virtual IP addresses of the virtual machines retained by the management system **10**.

(Supplement)

In this case, the management system **10** may manage operating statuses of all of the virtual machines, and simultaneously issue instructions for generating the virtual machines **50** to the servers **40** and notify virtual machine information to the controller **20**.

Also, when any of the servers **40** generates a virtual machine **50** to make it operate, the server **40** may directly or indirectly notify the management system **10** of a virtual MAC address and virtual IP address of the virtual machine **50**, and a physical MAC address thereof.

The router **60** is a relay unit that connects the switches **30** and an external network (such as the Internet). In FIG. **1**, as the router **60**, an access router and a center router are illustrated. The access router is a relay unit that connects the switches **30** and the center router. The center router is a relay unit that connects the access routers and the external network.

(Exemplification of Hardware)

Specific hardware examples for realizing the network system according to the present invention will be described below.

As an example of each of the management system **10**, the controller **20**, and the servers **40**, a computer such as a PC (personal computer), appliance, workstation, mainframe, and supercomputer is exemplified. As another example of each of the servers **40**, a mobile phone, a smart phone, a smart book, a car navigation system, a portable game machine, a home-use game machine, a gadget (electronic device), a bidirectional television, a digital tuner, a digital recorder, an information home appliance, a POS (Point of Sale) terminal, an OA (Office Automation) device, an intelligent copier, a digital signage, or the like is exemplified. Also, each of the management system **10**, controller **20**, and servers **40** may be an extension board mounted in a computer or the like, or a virtual machine (VM) constructed on a physical machine. The management system **10**, controller **20**, and servers **40** may be mounted in a moving object such as a vehicle, ship, or airplane.

As an example of each of the switches **30**, a network switch or the like is exemplified. Also, as an example of each of the routers **60**, a general router or the like is exemplified. As another example of each of the switches **30** and routers **60**, a proxy, a gateway, a firewall, a load balancer, a bandwidth controller/security monitoring controller (gatekeeper), a base station, an access point (AP), a communication satellite (CS), or a computer having a plurality of communication ports is exemplified.

As an example of the network connecting the management system **10**, the controller **20**, the switches **30**, the servers **40**, and the routers **60** to one another, a LAN (Local Area Network) is exemplified. As another example, the Internet, a wireless LAN, a WAN (Wide Area Network), a backbone, a cable television (CATV) line, a fixed phone network, a mobile phone network, the WiMAX (IEEE 802.16a), the 3G (3rd Generation), a leased line, the IrDA (Infrared Data Association), the Bluetooth (registered trademark), a serial communication line, data bus, or the like is also exemplified.

Although not illustrated, each of the management system **10**, the controller **20**, the switches **30**, the servers **40**, and the routers **60** is realized by a processor that operates on the basis of a program for executing a predetermined process, a memory that stores the program and various types of data, and a communication interface (I/F).

As an example of the above processor, a CPU (Central Processing Unit), a microprocessor, a network processor (NP), a microcontroller, a semiconductor integrated circuit (IC) having a dedicated function, or the like is exemplified.

As an example of the above memory, a semiconductor storage device such as a RAM (Random Access Memory), a ROM (Read Only Memory), an EEPROM (Electrically Erasable and Programmable Read Only Memory), or a flash memory, an auxiliary storage device such as an HDD (Hard Disk Drive) or an SSD (Solid State Drive), a removable disk such as a DVD (Digital Versatile Disk), a storage medium such as an SD (Secure Digital) memory card or the like is exemplified. Further, a buffer or a register is also exemplified. Alternatively, a storage device using a DAS (Direct Attached Storage), an FC-SAN (Fiber Channel-Storage Area Network), a NAS (Network Attached Storage), an IP-SAN (IP-Storage Area Network), or the like is also exemplified.

As an example of the above communication interface, a semiconductor integrated circuit such as a board (mother board or I/O board) corresponding to network communication, a network adaptor such as an NIC (Network Interface Card) or a similar expansion card, a communication device such as an antenna, a communication port such as a connecting port (connector), or the like is exemplified.

It should be noted that an internal configuration that realizes processing by each of the management system **10**, the controller **20**, the switches **30**, the servers **40**, and the routers **60** may be a module, a component, or a dedicated device, or alternatively an activating (invoking) program therefor.

It should be noted that, in practice, the present invention is not limited to any of such examples.

(Registering Process of Setting Information)

Referring to FIG. **3**, details of a registering process of setting information in the present exemplary embodiment will be described.

(1) Step S**101**

The management system **10** sets to the controller **20** as virtual machine (VM) information, the virtual MAC address and virtual IP address of the virtual machine **50** and the physical MAC address of the server **40** on which the virtual machine **50** operates.

(2) Step S**102**

The controller **20** retains as the virtual machine information, the virtual MAC address and virtual IP address of the virtual machine **50** and the physical MAC address of the server **40** on which the virtual machine **50** operates, on the basis of the settings by the management system **10**.

(3) Step S**103**

When any of the switches **30** is in a connection state with the server **40** under the switch and receives the ARP request from the server **40**, the switch **30** detects the physical MAC address of the server **40**, and notifies the physical MAC address of the server **40** to the controller **20**. At this time, the controller **20** sets a flow entry for a packet destined to the server **40** to the switch **30** on the basis of the physical MAC address of the server **40** by using the OpenFlow technique.

(4) Step S**104**

The controller **20** checks the retained physical MAC address of the server and the physical MAC address of the server notified from the switch **30**, and relates the physical MAC addresses to each other if the physical MAC addresses match to each other. Then, the controller **20** sets to the switch **30**, the flow entry for the packet destined to the virtual machine **50** on the basis of the virtual MAC address and virtual IP address of the virtual machine **50** on the server.

(5) Step S**105**

The server **40** generates the virtual machine **50** by a virtual machine monitor (VMM) such as a hypervisor and makes it operate.

(6) Step S**106**

After the flow entry for the packet destined to the virtual machine **50** is set, the switch **30** receives the ARP request from the virtual machine **50**. Here, the switch **30** transfers the ARP request from the virtual machine **50** to the controller **20**.

(7) Step S**107**

The controller **20** receives the ARP request from the virtual machine **50** through the switch **30**, and refers to the virtual machine information to send the ARP response back to the virtual machine **50**.

(Changing Process of Setting Information)

Referring to FIG. **4**, details of a changing process of setting information in the present exemplary embodiment will be described.

(1) Step S**201**

When the physical MAC address of the server on which the virtual machine **50** operates is changed, the management system **10** again sets the virtual MAC address and virtual IP address of the virtual machine and the physical MAC address of the server after the change, to the controller **20** as virtual machine (VM) information. At this time, the management system **10** may reset only the physical MAC address of the server to the controller **20** on the basis of content after the change.

(2) Step S**202**

When the change of the physical MAC address of the server **40** on which the virtual machine **50** operates, is notified on the basis of the settings by the management system **10**, the controller **20** sets the change of the flow entry for the packet destined to the virtual machine **50** to the switch **30**.

(3) Step S**203**

The virtual machine **50** migrates from the server **40** by a virtual machine (VMM) monitor such as a hypervisor.

(4) Step S**204**

The switch **30** corresponding to the server **40** as a migration destination of the virtual machine **50** receives the ARP request from the migrated virtual machine **50** after the flow entry for the packet destined to the virtual machine **50** is set. Here, the switch **30** transfers the ARP request from the virtual machine **50** to the controller **20**.

(5) Step S**205**

The controller **20** receives the ARP request from the virtual machine **50** through the switch **30**, and refers to the virtual machine information to send the ARP response back to the virtual machine **50**.

(Configuration Example of Controller)

A configuration of the controller according to the present invention is represented as functional blocks on the basis of the above content.

As illustrated in FIG. **5**, the controller **20** according to the present invention is provided with a storage section **21**, a detecting section **22**, and a setting section **23**.

The storage section **21** stores virtual machine information set by the management system **10**, i.e., the virtual MAC address and virtual IP address of the virtual machine, and the physical MAC address of the server with the virtual machine operating thereon. In this case, the storage section **21** also stores the virtual MAC address and virtual IP address of the virtual machine **50**, and the physical MAC address of the server **40** with the virtual machine **50** operating thereon.

The detecting section **22** detects the physical MAC address of the server **40** under the switch **30**, through the switch **30**. Here, the detecting section **22** detects the physical MAC address of the server **40** by receiving through the switch **30**, a packet that includes the physical MAC address of the server **40** in a source address region of header information. In addition, the detecting section **22** may store the detected information in the storage section **21**.

The setting section **23** checks the physical MAC address of the server set by the management system **10** and the physical MAC address of the server **40** detected through the switch **30**, and relates the physical MAC addresses to each other, if the physical MAC addresses match to each other, and sets to the switch **30** a flow entry for a packet destined to the virtual machine **50** on the basis of the virtual MAC address and virtual IP address of the virtual machine **50** on the server **40**.

The storage section **21**, the detecting section **22**, and the setting section **23** are realized by a processor driven on the basis of a program to execute a predetermined process, a memory that stores the program and various types of data, and a communication interface (I/F).

[Second Exemplary Embodiment]

In the following, a second exemplary embodiment of the present invention will be described.

In the first exemplary embodiment of the present invention, the switch **30** detects identification information of the server **40** under its control, and notifies the identification information of the server **40** to the controller **20**. If the identification information of the server **40** set by the management system **10** and the identification information of the server **40** notified from the switch **30** match to each other, the controller **20** calculates a route for communication with the server **40**, and sets a flow entry for a packet destined to the server **40**, to the switch **30**.

However, when it is previously known which server is present under which switch, and the identification information of the server **40** under the switch **30** is set from the management system **10** to the controller **20** as identification information of the server **40**, it is not necessary for the controller **20** to check the identification information of the server

40 set by the management system **10** and the identification information of the server **40** notified from the switch **30**. In this case, the controller **20** can calculate the route for communication with the server **40** on the basis of only the identification information of the server **40** set by the management system **10** without the notification of the identification information of the server **40** under the switch **30** from the switch **30**, and can set the flow entry for the packet destined to the server **40** to the switch **30**.

<Relationship Between Exemplary Embodiments>

It should be noted that the above respective exemplary embodiments may be carried out in combination. For example, when it is previously known which server is present under a switch regarding only a part of the switches, it is considered that any of the switches under which the server is previously known is applied with the method in the second exemplary embodiment, and a switch under which the server is not previously known is applied with the method in the first exemplary embodiment.

<Supplemental Notes>

Part or all of the above-described exemplary embodiments can also be described in the following supplemental notes. However, in practice, the present invention is not limited to any of the following supplemental notes.

(Supplemental Note 1)

A network system includes:

a controller in which identification information of a virtual machine, and identification information of a server on which the virtual machine operates are set; and

a switch configured to detect identification information of a server under the switch, and notify the identification information of the server under the switch to the controller,

wherein, when the set identification information of the server and the identification information of the server under the switch notified from the switch match to each other, the controller sets a flow entry for a packet destined to the virtual machine to the switch based on the identification information of the virtual machine on the server.

(Supplemental Note 2)

The network system according to Supplemental note 1, further includes a management system configured to set the identification information of the virtual machine and the identification information of the server on which the virtual machine operates, to the controller,

wherein the controller sets a changed flow entry for the packet destined to the virtual machine to the switch, when a change of the identification information of the server on which the virtual machine operates, is notified from the management system during operation of the virtual machine.

(Supplemental Note 3)

A controller includes:

a storage part that retains identification information on a virtual machine, and identification information on a server that operates the virtual machine;

a detection part that, through a switch that transfers a received packet according to a set flow entry, detects identification information on a server under the switch; and

a setting part that, upon the detected identification information on the server and the retained identification information on the server matching with each other, on a basis of the identification information on the virtual machine on the server, sets in the switch a flow entry for a packet destined to the virtual machine.

(Supplemental Note 4)

A network management method includes:

setting identification information of a virtual machine and identification information of a server which the virtual machine operates, to a controller;

detecting identification information of a server under a switch by the controller through the switch; and

setting a flow entry for a packet destined to the virtual machine to the switch based on the detected identification information of the virtual machine on the server, when the set identification information on the server and the detected identification information of the server match to each other.

(Supplemental Note 5)

The network management method according to Supplemental note 4, further includes:

setting the identification information of the virtual machine and the identification information of the server on which the virtual machine operates, to the controller by a management system; and

setting a changed flow entry for the packet destined to the virtual machine to the switch when a change of the identification information of the server on which the virtual machine operates, is notified from the management system to the controller during operation of the virtual machine.

(Supplemental Note 6)

A storage medium that stores a program which makes a computer to execute:

retaining identification information of a virtual machine, and identification information of a server on which the virtual machine operates;

detecting identification information of a server under the switch through a switch that transfers a reception packet based on a set flow entry; and

setting a flow entry for a packet destined to the virtual machine on the server to the switch based on the identification information of the virtual machine on the server, when the detected identification information of the server and the retained identification information of the server match to each other.

<Features of the Present Invention>

As described above, the present invention targets the CU separate-type network such as the OpenFlow network. It should be noted that the OpenFlow network is only an example. Actually, the present invention can also target a network in which a route control other than “flow control using the OpenFlow technique” is performed.

In the present invention, in parallel to the generation and migration of a virtual machine, a flow entry is set to a switch. That is, the setting of the flow entry to the switch is completed prior to the start of communication of the virtual machine.

In the present invention, the identification information of a virtual machine and the identification information of a server on which the virtual machine operates, are set to the controller by an external management system. The controller can grasp the identification information of the virtual machine operating on the server through a switch, by detecting the identification information of the server under the switch, and by checking the detected information with the set identification information of the server. For this reason, it is not necessary for the controller to inquire the identification information of the virtual machine every time a virtual machine is generated. Accordingly, a load of the controller is greatly reduced, as compared with a case where the present invention is not applied.

In the above, the exemplary embodiments of the present invention have been described in detail. However, in practice, the present invention is not limited to any of the above-described exemplary embodiments, and any modification without departing from the scope of the present invention is also included in the present invention.

It should be noted that this application claims a priority based on Japanese Patent Application No. JP 2010-202444. The disclosure thereof is incorporated herein by reference.

The invention claimed is:

1. A network system, comprising:

a management system configured to manage a network;

a switch on said network, said switch configured to include a flow entry in which a rule and an action are defined, to execute the action of the flow entry to a target packet; and

a controller configured to retain information of a server under said switch based on a setting by said management system,

wherein said server is configured to include a virtual machine being operable on said server,

wherein said management system is configured to include information of said virtual machine, and to provide said information of said virtual machine to said controller,

wherein said switch is configured to detect information of said server, and to notify the information of said server to said controller,

wherein said controller is further configured:

to calculate a communication route to said server based on said information of said server;

to relate said information of said virtual machine to said information of said server, based on said setting by said management system;

to retain a relation between said information of said virtual machine and said information of said server;

to check said information of said virtual machine with said information of said server; and

to set a new flow entry for a packet destined to said virtual machine to said switch based on said information of said virtual machine when said information of said virtual machine matches said information of said server,

wherein said server generates said virtual machine which operates on said server,

wherein, after the new flow entry for the packet destined to the virtual machine is set, said switch receives an Address Resolution Protocol (ARP) request from said virtual machine,

wherein said switch transfers the ARP request from the virtual machine to the controller, and

wherein the controller receives the ARP request from the virtual machine through the switch and refers to said information of said virtual machine to send the ARP response back to the virtual machine.

2. The network system according to claim **1**, wherein said controller sets a changed flow entry for the packet destined to said virtual machine to said switch, when a change of the server information of said server on which said virtual machine operates is notified from said management system while said virtual machine operates.

3. The network system according to claim **1**, wherein said management system sets to the controller as the virtual machine information, a virtual MAC address, a virtual IP address of the virtual machine, and a physical MAC address of the server on which the virtual machine operates.

4. The network system according to claim **1**, wherein the management system manages the network by using hardware and software configurations for realizing an NMS (Network Management System) or an EMS (Element Management System).

5. The network system according to claim **1**, wherein the management system sets a virtual MAC address, a virtual IP address of the virtual machine, and a physical MAC address of a server on which the virtual machines operate to the controller, as the virtual machine information.

6. The network system according to claim **5**, wherein the virtual machine information is set in advance in the management system.

7. The network system according to claim **1**, wherein the server generates said virtual machine by a virtual machine monitor.

8. The network system according to claim **7**, wherein the virtual machine monitor comprises a hypervisor.

9. A controller, comprising:

means for storing information of a server set by a management system which manages a network provided with a switch,

wherein said switch is configured to include a flow entry in which a rule and an action are defined, to execute the action of the flow entry to a target packet,

wherein the controller is configured to retain information of a server under said switch based on a setting by said management system,

wherein said server is configured to include a virtual machine being operable on said server,

wherein said management system is configured to include information of said virtual machine and to provide said information of said virtual machine to said controller,

wherein said switch is configured to detect information of said server and to notify the information of said server to said controller,

wherein said controller is further configured:

to calculate a communication route to said server based on said information of said server;

to relate said information of said virtual machine to said information of said server, based on said setting by said management system;

to retain a relation between said information of said virtual machine and said information of said server;

to check said information of said virtual machine with said information of said server; and

to set a new flow entry for a packet destined to said virtual machine to said switch based on said information of said virtual machine when said information of said virtual machine matches said information of said server,

wherein said server generates said virtual machine which operates on said server,

wherein, after the new flow entry for the packet destined to the virtual machine is set, said switch receives an Address Resolution Protocol (ARP) request from said virtual machine,

wherein said switch transfers the ARP request from the virtual machine to said controller, and

wherein said controller receives the ARP request from the virtual machine through the switch and refers to said information of said virtual machine to send the ARP response back to the virtual machine.

10. The controller according to claim **9**, further comprising means for setting a changed flow entry for the packet destined to said virtual machine to said switch, when a change of the information of said server on which said virtual machine operates is notified from said management system while said virtual machine operates.

11. A network managing method which is executed by a computer, said network managing method comprising:

executing an action of a flow entry to a target packet by a switch on said network, said switch being configured to include the flow entry in which a rule and the action are defined; and

retaining, by a controller, information of a server under said switch which is set by a management system which manages a network,

wherein said server is configured to include a virtual machine being operable on said server,

wherein said management system is configured to include information of said virtual machine and to provide said information of said virtual machine to said controller,

wherein said switch is configured to detect information of said server and to notify the information of said server to said controller,

wherein said controller is configured:

to calculate a communication route to said server based on said information of said server;

to relate said information of said virtual machine to said information of said server, based on said setting by said management system;

to retain a relation between said information of said virtual machine and said information of said server;

to check said information of said virtual machine with said information of said server; and

to set a new flow entry for a packet destined to said virtual machine to said switch based on said information of said virtual machine when said information of said virtual machine matches said information of said server,

wherein said server generates said virtual machine which operates on said server,

wherein, after the new flow entry for the packet destined to said virtual machine is set, said switch receives an Address Resolution Protocol (ARP) request from said virtual machine,

wherein said switch transfers the ARP request from the virtual machine to said controller, and

wherein said controller receives the ARP request from the virtual machine through the switch and refers to said information of said virtual machine to send the ARP response back to the virtual machine.

12. The network managing method according to claim **11**, further comprising:

setting a changed flow entry for the packet destined to said virtual machine to said switch, when a change of the

information of said server on which said virtual machine operates is notified from said management system while said virtual machine operates.

13. A non-transitory storage medium which stores a program to make a computer execute:

conducting an action of a flow entry to a target packet by a switch on said network, said switch being configured to include the flow entry in which a rule and the action are defined; and

retaining, by a controller, information of a server under said switch which is set from a management system which manages a network,

wherein said server is configured to include a virtual machine being operable on said server,

wherein said management system is configured to include information of said virtual machine and to provide said information of said virtual machine to said controller,

wherein said switch is configured to detect information of said server and to notify the information of said server to said controller,

wherein said controller is configured:

to calculate a communication route to said server based on said information of said server;

to relate said information of said virtual machine to said information of said server, based on a setting by said management system;

to retain a relation between said information of said virtual machine and said information of said server;

to check said information of said virtual machine with said information of said server; and

to set a new flow entry for a packet destined to said virtual machine to said switch based on said information of said virtual machine when said information of said virtual machine matches said information of said server,

wherein said server generates said virtual machine which operates on said server,

wherein, after the new flow entry for the packet destined to said virtual machine is set, said switch receives an Address Resolution Protocol (ARP) request from said virtual machine,

wherein said switch transfers the ARP request from the virtual machine to said controller, and

wherein said controller receives the ARP request from the virtual machine through the switch and refers to said information of said virtual machine to send the ARP response back to the virtual machine.

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